What is claimed is:

Sub
a1

1. A system for controlling the physical behavior of an apparatus, the behavior of the apparatus estimated by an initial behavioral model, the system comprising:

a sensor element located in proximity to the apparatus for acquiring data indicative of the physical behavior of the apparatus;

a system processor which includes a tunable controller based on the initial behavioral model, the processor capable of generating a drive signal, estimating a behavioral model, tuning and adjusting the controller and generating a control signal,

wherein the processor adapts the initial model to an updated model based upon the gathered data, combines the updated model with a universal filter to create a relation that describes the behavior of the apparatus and creates a controller based on the relation such that the controller is tuned according to the updated model, and

wherein the control signal generated by the processor according to the controller is used to control the physical behavior of the apparatus.

2. The system of claim 1, wherein the drive signal causes motion in the apparatus.

3. The system of claim 1, wherein the relation is formulated as an optimal control problem.

4. The system of claim 3, wherein the relation is solved by a method chosen from the group of methods consisting of: linear quadratic gaussian (LQG), H-infinity and μ-synthesis.

5. The system of claim 1, wherein the universal filter includes a set of numbers provided by a user of the system.

6. The system of claim 1, wherein the universal filter is

$$\begin{bmatrix} z \\ r \\ y \end{bmatrix} = \underbrace{\begin{bmatrix} E_1 & E_2 & E_3 \\ F_1 & D_1 & 0 \\ F_2 & 0 & D_2 \end{bmatrix}}_{F} \begin{bmatrix} w \\ u \\ s \end{bmatrix}$$

where E_1, E_2, E_3, D_1,D_2, F_1, and F_2 are filters that specify the relationship between a disturbance, w, at least one performance variable of the apparatus, z, at least one controller input to the apparatus, y, at least one controller output, u, at least one plant input, r, and at least one plant output, s.

7. The system of claim 1 wherein the controller is a digital signal processor (DSP).

8. The system of claim 1 further comprising a second processor in data communication with the system processor.

9. The system of claim 8, wherein the second processor is portable from the location of the system processor.

10. The system of claim 1, wherein the system begins acquiring data upon occurrence of a predefined event.

11. The system of claim 10, wherein the predefined event is an event selected from the group of events consisting of: input received from an operator, exceeding a threshold operating value in the apparatus, and the passage of a predetermined length of time.

12. The system of claim 1, further comprising an actuator in electrical communication with the system processor, wherein the drive signal causes activation of the actuator and wherein the actuator is located such that the physical behavior of the apparatus is modified by the activation of the actuator.

13. The system of claim 12, wherein transfer function data is collected between the actuator and the sensor element.

14. The system of claim 13, wherein the sensor element gathers frequency data and wherein the accuracy of the updated model is adjustable as a function of the gathered frequency data.

15. The system of claim 1, wherein the system processor further includes a signal conditioner.

16. The system of claim 1, wherein the system processor further includes a signal amplifier.

17. The system of claim 1, wherein the updated model is a model of minimal order.

18. The system of claim 1, wherein the relation is a multivariate and fully coupled.

19. The system of claim 1, wherein the processor creates the updated model by non-linear curve-fitting thereby describing the updated model by a known mathematical equation according to the data gathered by the sensor.

20. The system of claim 19, wherein an error function is associated with the known mathematical equation, the error function including log magnitude and phase information.

21. The system of claim 13, wherein the logarithmic error between the collected data and the initial behavioral model is:

$$\hat{\theta} = \arg\min_{\theta} \sum_{i=1}^{p} \sum_{j=1}^{q} \sum_{k=1}^{N} \left| \log\left(\frac{\hat{G}_{ij}(f_k, \theta)}{G_{ik}(f_k)} \right) \right|^2 ,$$

where θ is a vector of parameters which describe the model, $\hat{G}_{ij}(f_k, \theta)$ is the frequency response of the model from actuator j to sensor i measured at frequency f_k, $G_{ik}(f_k)$ is the measured frequency response from actuator j to sensor i measured at frequency f_k. p is the number of sensors, q is the number of actuators, and N is the number of frequency points of interest.

22. A system for governing a controller of the type usable to dictate motion of a machine component in normal use, comprising:

a sensor which measures data that accurately characterizes the physical behavior of the component, the data measuring occurring during an abnormal period triggered by an event, the measured data being indicative of the behavior of the machine component when in normal use; and

a signal processor which dynamically generates and uses a multivariable, fully-coupled mathematical relation of minimal order in conjuction with a universal filter to create a controller, the controller dictating motion after the abnormal period has ceased and when the equipment component is in normal use.

23. The system of claim 22, wherein the mathematical relation provides an accurate model of the normal motion characteristics of the equipment component and the controller is created by using a method chosen from the group of methods consisting of: linear quadratic gaussian (LQG), H-infinity and μ-synthesis.

24. The system of claim 23, wherein the mathematical relation includes at least one parameter for governing the controller and wherein the parameter is a function of data measured by the sensor.

25. A method for governing motion in a physical system, the physical system being estimated by an initial behavioral model, comprising the steps of inducing motion in the physical system, measuring frequency data which characterizes the motion in the system, updating the initial behavioral model to create an updated behavioral model which accurately conforms to the measured data, using the updated behavioral model in conjunction with a universal filter to create a command structure and applying appropriate stimulus to the system to cause motion in the physical system, thereby causing the physical system to behave in accordance with the command structure.

26. A method for creating an updated model for the motion characteristics of a physical system from a previously stored model of the system, the updated model governing the actions of a system controller which dictates motion in the physical system, comprising the steps of:

detecting the occurrence of a start event;

gathering data relating to the motion characteristics of the physical system;

updating the stored model by comparing the gathered data to the stored model; and

iteratively adapting the stored model until the stored model predicts the motion characteristics of the system according to the gathered data; and

storing the updated model at an electronic memory location accessible to the system controller.

a1

27. The method of claim 23, wherein the step of gathering data comprises acquiring a frequency response to an induced motion to the physical system.

28. The method of claim 23, wherein the step of comparing the data comprises fitting a non-linear curve to the gathered data.

29. A method for controlling movement of a mechanical apparatus based on the spatial location of a movable portion of the mechanical apparatus, the movement of the portion initially estimated by a first mathematical model and governed by a first controller which is based on the first mathematical model and a mathematical filter, comprising the steps of:

introducing a first signal to induce motion in the movable portion;

measuring the motion and spatial location of the movable portion in response to the first signal;

updating the first mathematical model to generate a second mathematical model which approximates the motion of the movable portion and updating the first controller using the second mathematical model and the filter to create and solve an optimal control problem and thereby generate a second controller, such that the motion induced when a second signal is applied to the mechanical apparatus is well-predicted.

30. A method of creating a controller of the type employed by a user to govern motion in a physical system comprising the steps of:

generating an identification of the system by measuring the response of the system to commands;

accepting input from the user specifying certain parameters of the system;

applying a universal filter to the input from the user to create a user-defined behavioral range for the physical system;

creating a problem specification from the identification of the system and the behavioral range; and

solving the problem specification, thereby creating the controller.

31. A system for creating a controller of the type used by a user to govern motion in a physical system comprising:

means for generating an identification of the system by measuring the response of the system to commands;

means for accepting input from the user specifying certain parameters of the system;

means for applying a universal filter to the input from the user to create a user-defined behavioral range for the physical system;

means for creating a problem specification from the identification of the system and the behavioral range; and

means for solving the problem specification, thereby creating the controller.

Add a1